CHAPTER 5

INTERIOR WALLS, PARTITIONS, AND CEILINGS

SECTION I—INTRODUCTION

5.1.1 General

This chapter considers the various types of interior walls, partitions and ceilings and describes methods and procedures for their maintenance and repair. In addition to the requirements for strength, color, durability, and other qualities for construction purposes, properties directly affecting safety, acoustical characteristics and thermal insulation value of the finish material must be considered.

5.1.2 Types of Interior Walls and Partitions

Interior walls and partitions are usually constructed of wood studs, metal studs, blocks, or structural clay tile with a plaster, gypsum board or ceramic tile finish. Others are constructed of glazed structural units, brick, block (painted or unpainted), metal, or glass.

5.1.3 Types of Ceilings

Ceilings are usually gypsum board, plaster, acoustical tile, or metal, either applied directly to the underside of the floor or roof framing or supported by a suspended grid system.

5.1.4 Interior Finishes

5.1.4.1 *Plaster.* The various types of plaster are similar in composition and application but are designed for specialized uses.

a. Gypsum Plaster. Gypsum plaster is most generally used in ordinary construction because it can be readily applied to furred and lathed surfaces of exterior masonry and directly to interior masonry. It can be applied over metal lath and gypsum products. High-grade, high-strength gypsum plaster is generally limited to use in neuropsychiatric sections of hospitals. Gypsum plaster should conform to ASTM C-631 and C-28.

b. Lime Plaster. Lime plaster, found in many older buildings, is similar in application to gypsum plaster but should not be used in conjunction with gypsum products. Lime plaster should be repaired with like material.

c. Keene's Cement Plaster. Keene's cement plaster produces a hard, moisture-resistance surface, suitable for spaces given hard use, particularly wainscots, and areas subject to continued moisture, such as baths, kitchens, and certain hospital areas. Keene's cement plaster should be applied only over a gypsum plaster base and should conform to Federal Specification SS-C-161A.

d. Portland Cement Plaster. Portland cement plaster may be applied directly to interior masonry walls and over metal lath; it should never be applied over gypsum products. It is recommended for use in plastering walls and ceilings of large, walk-in refrigerators and other cold-storage spaces, basement spaces, toilets, showers, janitorial closets, and similar areas where Keen's cement plaster is not economically justifiable.

e. Insulating Plaster. Insulating plaster differs from other plasters in that lightweight vermiculite and perlite are used as an aggregate instead of sand. It is lightweight, provides some thermal insulation, and gives a fire-retardant surface, to a degree determined by its composition and method of application.

5.1.4.2 *Tile.* Ceramic tile, structural clay tile, glazed structural units, and similar water-resistant materials are commonly used for interior walls and wainscoting where moisture conditions and cleanliness are factors. Structural clay tile is used primarily for interior partitions and for backup for brick walls. Tile finishes and wainscoting are used in toilets, baths, kitchens, and certain hospital spaces.

5.1.4.3. *Wallboard.* Gypsum wallboard should conform to ASTM C840 or C-36. It is composed of a gypsum core encased in a heavy manila-finished sheet on the face side, and a strong liner paper on the back. Hard-pressed fiberboard may be used as wainscoting only when backed with noncombustible material, such as gypsum wallboard. Structural-type fiberboard should conform to Federal Specification LLL-B-810. Where moisture resistance or extra strength is required, Class II or Class IV treated fiberboard should be used; otherwise, Class I is satisfactory. Wallboard, in general, is used where conditions of occupancy do not subject it to severe services.

5.1.4.4 *Metal.* Interior walls, partitions, or ceilings of metal (steel, aluminum, etc.) are normally used in industrial and office-type buildings and structures to withstand hard use or to contain hazardous operations. Other common uses of metal include office partitions, toilet partitions, and sleeping cubicles.

5.1.5 Functions and Characteristics

5.1.5.1 *General.* In the maintenance and repair of buildings and structures, care should be taken to maintain the effectiveness of interior finishes as to fire resistance, insulation and acoustical functions.

5.1.5.2 *Fire Resistance.* Conventional wall construction materials, such as gypsum block surfaced with plaster of the required thickness, brick, concrete, hollow tile, and concrete block, are considered nonhazardous and noncombustible. Partitions or ceilings constructed of assemblies of wood or metal studs or joists, or of metal, gypsum, or wood lath, surfaced with cement, lime, or vermiculite plaster, are considered nonhazardous. A sheet-metal covering applied directly to wood joists or over old plaster ceilings, although superior to highly combustible materials, offers little resistance to fire and increases the effort required to extinguish fires in concealed spaces, such as between joists.

5.1.5.3 *Insulation.* Noncombustible materials used for insulation of buildings and structures against heat or cold, such as mineral or glass wool, have a secondary effect of increasing fire resistance, if they stay in place and do not settle to create voids. Rigid insulating boards of polyurethane and perlite are also used on walls.

5.1.5.4 *Noise Control.*

a. Sound Absorption. Acoustical materials applied on walls, partitions, and ceilings absorb noise and aid hearing by reducing echoes and reverberation. Porous or low-density materials, similar to those used for thermal insulation, are commonly applied in theaters, auditoriums, and other areas where good acoustics are required. The materials should be noncombustible or fire-resistant, such as mineral and glass wool and laminated gypsum wallboard attached to the framing with resilient clips.

b. Exterior Sound. Insulation from exterior noise is sometimes part of the interior sound-absorption problem. The best resistance to noise penetration usually can be obtained with heavy rigid walls and floors, or multiple-layer construction separated by airspaces. Such construction keeps out sound by preventing the vibration of wall or floor. Any mechanical connection across the intervening airspace in a structurally separated wall increases sound transmission. For hollow walls not structurally separated, such as ordinary wood-stud partitions, a fill of noncombustible material between the studs slightly improves the sound insulation.

5.1.5.5 *Cleanability.* In general, ceramic tile, glass, glazed-faced masonry, and similar hard-surfaced materials are more easily cleaned and are more resistant to moisture and staining than plaster, wood, and metal.

5.1.6 Accessory Materials

5.1.6.1 *Lath.* Metal lath should conform to Federal Specification QQ-L-1O1. It may be expanded metal, woven wire mesh, or woven wire fabric, with a paper or other backing. Gypsum lath or rock lath, conforming to Federal Specification SS-L-30D, is available in solid, perforated, and insulating types. Expanded metal lath should be used to replace wood lath in all rehabilitation work. It should be placed with the long side of the sheet perpendicular to the supports, and then be nailed or stapled to wood supports and wired to metal supports. In hanging laths for ceilings, the joints should be broken so alternate sheets run through, to avoid plaster cracks. When gypsum lath is used, all joints should be staggered so that joints do not meet on the same stud or at the ceiling line.

5.1.6.2 *Furring.* Furring consisting of wood or metal strips serves as a framework for lath; it may be used to level uneven wood partitions or ceiling framing or masonry wall surfaces, or to provide a dead airspace in walls for insulation.

5.1.7 Plastering Accessories

To obtain a satisfactory plaster surface, a number of accessories are required.

5.1.7.1. *Grounds.* Grounds are wood strips of uniform thickness installed around all openings, at the bottom of walls near the floor, at the top of wainscots, at chair-rail heights, and other places where trim is required. They serve as a guide in bringing the plaster to a uniform thickness for an even surface, form a stop against which the plaster is finished, and furnish means for fastening the interior trim to the walls. Temporary wood grounds are often used in gauging the thickness of the scratch and brown coats of plaster.

5.1.7.2 *Base Screeds.* Base screeds, like plaster grounds, serve as a guide to gauge the plaster thickness and as plaster stops. Screeds are used at the bottom of plaster walls where the plaster joins the floor base, or where it joins the wainscot in walls with tile or other similar materials used as bases or wainscots.

5.1.7.3 *Corner Beads.* Corner beads should be installed at all external plaster corners. They serve a dual purpose: as a plaster stop gauge for acquiring a uniform surface finish, and as a reinforcement to strengthen plaster corners to prevent them from being broken off. Corner beads are manufactured in two all-metal styles: the bullnose bead, which is a wide-radius bead and is designed especially for corners receiving unduly hard use; and the standard bead, which has a very small radius and is designed to provide sharp, clean corners. A corner bead suitable for installation on plasterboard (dry wall) corners is a fabricated product consisting of a ¾-inch hard metal strip, formed to a right angle and glued under pressure to a 2-inch strip of fabric or tough, treated paper. Specially constructed beads are available for forming arches and other irregular corners.

5.1.7.4 *Corner Lath.* The corner lath is an angle-shaped strip of lath with 2- or 3-inch legs, usually installed at an interior vertical or horizontal plaster corner as a reinforcement to prevent cracking of the plaster. Corner laths may be procured in preformed strips or be cut from metal lath sheet and formed on the job to fit the particular corners in which they are to be installed. Corner laths should be fastened at the edges, with staples used over wood and lath and wire over metal lath. Corner laths should not be fastened by nailing through into the framing because stresses in the structure will then be transmitted directly into the plaster, causing a crack.

5.1.7.5 *Strip Lath.* A strip lath, as the term indicates, is a strip of metal lath, 4 or more inches wide, intended for application over joints of dissimilar plaster-base materials where the surfaces to be plastered lie in the same plane and cannot be effectively bonded or tied together without the help of metal lath strips. Each corner of a door, window, or other opening in a plastered surface will have a 12- by 24-inch strip of metal lath fastened over the plaster base at an angle in relation to the opening of approximately 45°. Such additional reinforcing is not required over metal lath.

SECTION II—REPAIR AND MAINTENANCE OF PLASTER AND TILE

5.2.1 Application of Plaster

5.2.1.1 *Preparation.* Before plastering is started, the plaster base, whether masonry or lath, and the grounds should be inspected. The existence and location of plumbing, heating, and electrical outlets should be checked.

5.2.1.2 *Bond.* A secure bond between plaster and base is necessary to develop strength and resistance to damage in walls and ceilings. A "mechanical" bond is formed when plaster is pressed through the mesh of metal lath or the holes of perforated board lath, forming keys on the other side. A "suction" bond is formed when plaster is applied over nonperforated gypsum or insulation board lath and over a masonry base. In suction bonding, the small, needlelike plaster crystals penetrate the surface pores of the base by suction; when the plaster sets, the base and plaster become "welded" together. When perforated board lath is used, both mechanical and suction bonds are developed.

5.2.1.3 *Plaster System.* Plaster is applied in a series of coats called scratch, brown, and finish. Application and mixes vary to meet conditions imposed by original construction on which the plaster is applied and by the area of use. Three-coat work is generally advisable over metal lath while two-coat work often suffices over masonry and gypsum lath and gypsum partition tile. Consideration will always be given to the use of light plaster aggregate, such as perlite and vermiculite, for insulation value and to materials with fireproofing characteristics, such as gypsum board, metal lath and other components, for wall surfaces under repair. Proper drying and settling of one coat before another coat is applied is necessary for good plastering. Adequate ventilation is required for good drying. If the entire building is enclosed and heated, fans may be used to eliminate dead airspaces and facilitate drying.

a. Scratch Coat. The scratch coat consists of a mixture of sand or lightweight aggregate and plaster. The sand or aggregate is increased for a scratch coat over masonry. Sufficient material and pressure must be applied to form full keys on metal lath or a good bond on masonry. The scratch coat is left with a rough surface to accept the next coat.

b. Brown Coat. The brown coat is similar to the scratch coat except that sand or aggregate content is increased. It is applied after the scratch coat has set firm and hard. The brown coat is laid flush to the grounds, straightened to form a true surface and left rough.

c. Finish Coat Float or sand finish is achieved by using a rubber or carpet float. The float finish of gypsum vermiculite should be placed only on base coats of gypsum lightweight aggregates. Recommended proportions for this finish coat are 1 part gypsum gauging plaster, 5 parts lime putty, **a** to **b** part fine, white sand or lightweight aggregate fines.

5.2.2 Causes and Signs of Plaster Damage

Cracks, holes and looseness in plastered surfaces are signs of excessive internal or external stresses. They may be caused by poor workmanship, such as improper proportions or application of the plaster, imperfect lathing, and poor atmospheric conditions during plastering; or by moisture infiltration or an excess of moist air generated inside a building frame. External stresses that cause plaster damage should be investigated and corrected before repairs are made to the plastered surfaces themselves.

5.2.3 Plastering Equipment

Equipment for making minor repairs consists of a spatula or putty knife, a small diamond-shaped pointing trowel, a sharp chisel, a linoleum knife, a hammer, and a shallow mixing pan.

5.2.4 Patching

5.2.4.1 *Structural Cracks.* Generally, two coats of patching material are required to repair wide structural cracks.

a. The first coat may be a job mix composed of 1 part fibered gypsum plaster and 2½ parts plastering sand, by volume, mixed with clean water to a uniform color and workable consistency.

b. Material for the second coat may be either a neat gypsum plaster or a mix of 1 part hydrated lime and ½ part calcined gypsum mixed with water to a suitable consistency.

c. A small amount of casein glue added to the above mix insures easier application because it tends to retard the setting time of the mix. The addition of glue also prevents shrinking of the mix and helps form a better bond with the old plaster.

d. In lieu of the mixes described in (a) and (b) above, a commercial patching plaster may be used. This material, known as spackling compound, is a mixture of plaster of Paris and powdered glue, which is mixed with clean water to the consistency of soft putty.

e. The quantity of any patching material must not exceed that which can be applied within 30 minutes after mixing. Plaster material should not be retempered (by adding water) once it has begun to dry out and harden. Retempered plaster placed on the wall will dry and become soft and crumbly.

5.2.4.2 *Map Cracks.* Best patching results in the repair of medium-width map cracks are usually obtained by use of the spackling compound described in (d) above.

5.2.4.3 *Hairline Shrinkage Cracks.* One method of filling hairline shrinkage cracks is to mix spackling compound to a thin paste and scrub it into the cracks.

5.2.5 Repair of Gypsum and Lime Plaster

Identification of failures in gypsum and lime plaster surfaces, possible causes, failure and methods of repair are discussed below.

5.2.5.1 *Structural Cracks.* Structural cracks are easily identified because they are usually large and well defined, extending across the surface and entirely through the plaster. They generally develop during the first year after completion of construction and, in most cases, can be successfully and permanently repaired. However, before repairs are initiated, the cause of the failure should be determined from an engineering standpoint and necessary precautions taken to prevent recurrence of the failure. Structural cracks may extend diagonally from the corners of door and window openings, run vertically in corners where walls join, run horizontally along the junction of walls and ceilings, or occur in walls where two unlike materials join.

a. Causes. Structural cracks may be caused by one or more structural defects, such as foundation settlement; failure of masonry wall section by shrinkage or cracking; sagging, warping, or shrinkage of wood frame members; insufficient bracing of wood frame members, or use of undersized or improperly spaced wood frame members.

b. Repair. To repair a structural crack, use a linoleum knife or chisel to cut out and remove loose material. The crack must be formed to a V-shape to provide adequate keying action by making the surface opening narrower than the bottom of the crack. Care should be exercised to widen the crack only enough to insure a good bond between patching plaster, old plaster, and lath. Expanded metal or wire lath should be cleaned and the mesh opened so that, when patching plaster is forced into the opening, a good key is formed. Break out the key between wood lath so that a new key can be formed when patching material is forced into place. Thoroughly wet wood lath before applying patching plaster. Brush out all loose material, remove all grease or dirt from surrounding surface areas, and wet the edges of the groove. Press the first coat of patching plaster firmly into place, filling the groove nearly to the surface; allow it to set until nearly dry but not hard; then complete the patch by applying a coat of finish plaster, strike off flush, and trowel smooth. If the edges of the old plaster and the wood lath are not thoroughly wetted, they serve as a wick to draw the water

from the fresh plaster, causing it to dry out, remain chalky, and crack around the edges of the patch. In applying the plaster, special attention should be given to the edges of the patch to insure a firm, solid bond between old and new plaster.

5.2.5.2 *Map Cracks.*

a. Map cracks are less noticeable than structural cracks. They penetrate through the plaster but do not extend entirely across the surface and generally occur as a series of irregular cracks running at various angles, embracing areas 6 inches or more in width and up to several feet in length. Map cracks are generally caused by improper bonding between the plaster and lath or masonry base and indicate inferior workmanship, the use of poor quality materials, or a combination of the two.

b. Repair. Normally map cracks are repaired in much the same manner as described for shrinkage cracks. Where large areas are badly cracked, the repair method for loose plaster, described in paragraph 5.2.5.4a, may be used.

5.2.5.3. *Shrinkage Cracks.*

a. Shrinkage cracks are sometimes referred to as crazing and resemble map cracks in appearance but are ordinarily confined to the finish coat. They do not extend entirely through the plaster surface, and cover a much smaller portion of the wall or ceiling surface. Shrinkage cracks generally result from careless workmanship, too rapid drying of the surface, insufficient troweling, troweling while the surface is still too wet, or by not troweling until the surface had become too dry.

b. Repair. Normally shrinkage cracks are repaired by filling with spackling compound. Where shrinkage cracks penetrate the base course and are of such extent that they will not retain such a paint mixture, they should be cut out and repaired in the same manner as described for structural cracks.

5.2.5.4 *Holes.* Holes are repaired in the same manner as structural cracks. Cutting out the loose plaster surrounding the hole requires extreme care not to loosen an unnecessary amount of sound plaster.

a. Loose Plaster. Loose plaster is indicated by bulging and cracking of large areas of the plaster surface. The extent of loosened plaster can be determined by lightly tapping the surface with a small hammer, with the resulting sounds indicating the extent of the loose area. Loose plaster may result from excessive moisture caused by leaks in the roof, seepage through an exterior wall, plumbing leaks, or heavy condensation. This excessive moisture causes the plaster to loosen. In some cases, the plaster may bulge or sag but continue to hang in this condition quite a long time before falling, held together only by the hair or fiber in the base coat. Occasionally moisture causes the fastenings holding the lath to the structural frame to corrode, permitting both the lath and plaster to bulge or sag. Another cause of bulging plaster is the use of incompletely hydrated lime in the plaster mix. In localities where high humidity is prevalent, moisture causes a continued hydration of the lime, which weakens the plaster and destroys the bond between plaster and base. This condition usually occurs in the spring and summer months, starting from the first to third year after plastering and continuing indefinitely.

b. Repair. Before repairing the damaged plaster, it is necessary to locate and eliminate the source of moisture. To prevent loose plaster from falling until permanent repair can be accomplished, temporary repair may be made by securing the loose plaster with a section of wallboard nailed securely to the wall or ceiling over the area affected. Nails should be of sufficient length to penetrate through the plaster and obtain a firm bearing in the studs or joists. Repairs of a permanent nature should be made as soon as practicable. Remove all loose plaster around the break, working back in the surrounding area to a point where solid plaster (well keyed to the lath, which, in turn, is solidly secured to the structural frames) is reached. Remove defective lath and replace with suitable plaster backing, such as metal lath or plasterboard, and securely refasten all lath that has become loosened.

5.2.5.6 *Old Plaster Surfaces.* Old, worn, crumbling plaster is repaired in the same manner as loose plaster. However, in the attempt to repair old plastered surfaces, the operation of removing the affected areas sometimes causes areas of apparently sound plaster to fall. This is evidence that the entire plaster surface has deteriorated to the extent that replastering of the whole area is necessary.

5.2.6 Repair of Keene's Cement Plaster

Keene's cement plaster is much harder and less susceptible to damage from moisture than gypsum and lime plasters and therefore requires much less maintenance and repair. Keene's cement plaster is normally used in areas subject to excessive moisture conditions, such as showers, toilets, baths, galleys, laundries, machinery and equipment rooms, and similar spaces. When repairs of Keene's cement plaster surfaces are necessary, the same principles described above for repair of gypsum plaster apply, with the exception that Keene's cement plaster should be used, in accordance with manufacturer's instructions, instead of patching plaster and gypsum plaster.

5.2.7 Repair of Portland Cement Plaster

Surfaces subjected to hard use or exposed to moisture, such as walls and ceilings of large walk-in refrigerators and cold storage spaces, exterior surfaces such as undersides of canopies and marquees, and other locations where, for economical reasons, Keene's cement plaster is not justifiable, are often coated with portland cement plaster. The types of failures and methods of repairing portland cement plaster are basically the same as described above for gypsum plaster. In patching small areas, the edges of the surface surrounding the defective area must be thoroughly and continuously wetted for at least 1 hour before application of the patching material. Just prior to applying the patch, dust the entire edge of the exposed plaster with a light coat of portland cement. Press the first coat of portland cement plaster, composed of 1 part portland cement, 3 parts plastering sand, and ¼ part lime putty, firmly into the groove or hole nearly to the surface, using particular care to insure that no voids are left around the perimeter of the patch. Scratch or roughen the surface of the patch with a wire brush or nail to make a base for receiving the finish coat. Thoroughly cure the patch by keeping it moist for at least 72 hours; then let it dry thoroughly, for not less than 7 days, prior to applying finish coat. Just prior to applying of the finish coat, moisten the patch thoroughly and firmly press the plaster into the remaining cavity, float to a smooth, even surface, and then trowel to the same texture as the surrounding surface. Keep the patch moist for at least 3 days.

5.2.8 Material Handling Precautions

All material in bags or bundles should be stacked, blocked, interlocked, and limited in height so that the pile is stable and secure against sliding or collapse. Judgment must be used in stacking and storing materials in any structure. Concentrated loads of stored materials can exceed the allowable uniform live load by 100 percent, if the loads are stacked adjacent to outside walls or over beam and column supports. *Never stack materials in the center of joist spans.* When material is placed in or encroaches on passageways, it should be located to present the least possible hazard. Limits of allowable loads will be determined through consultation with structural personnel of the installation engineer organization.

5.2.8.1 *Cement and Lime.*

a. Bags of cement and lime should not be stacked more than 10 bags high without stepback, except when restrained by walls of appropriate strength.

b. The bags around the outside of the stack should be placed with the mouths of the bags facing the center of the stack.

c. During unstacking, the entire top of the stack should be kept nearly level and the necessary step-backs maintained.

d. Handle cement and lime in paper bags with care to prevent bags from breaking.

e. Store lime and cement on off-the-floor platforms in dry spaces. Lime must be kept dry in storage to prevent possible premature slaking, which could cause fire.

5.2.8.2 *Personal Protective Measures.* Workmen will observe the following precautions:

a. Wear heavy gloves when handling metal lath.

b. Wear goggles for eye protection when handling cement and lime.

c. Wear shirts with closed neck and wristbands and insure that exposed parts of the body do not come in direct contact with lime.

d. Avoid wearing clothing that has become stiff and hard with cement or lime; such clothing irritates the skin and may cause infection.

e. Personal cleanliness and frequent washing are effective preventives of skin ailments.

5.2.9 Replacement Application of Ceramic Tile

5.2.9.1 *Scratch Coat.* A scratch coat for application as a foundation coat must be not less than ¼ inch thick and composed of 1 part cement to 3 parts sand, with the addition of 10-percent hydrated lime by volume of the cement used. While still plastic, the scratch coat is deeply scored or scratched and cross-scratched. The scratch coat should be protected and kept reasonably moist during the seasoning period. All mortar for scratch and float coats must be used within 1 hour after mixing. The retempering of partially hardened mortar should not be permitted. The scratch coat must be applied not more than 48 hours, nor less than 24 hours, before starting the setting of title.

5.2.9.2 *Float Coat.* The float coat should be composed of 1 part cement, 1 part hydrated lime, and 3½ parts sand. It must be brought flush with screeds or temporary guide strips, well placed to give a true and even surface at the proper distance from the finished face of the tile.

5.2.9.3. *Setting Wall Tile.* Wall tile should be thoroughly soaked in clean water before it is set. It is set by neatly troweling a skim coat of portland cement mortar on the float coat, or applying a skim coat to the back of each tile unit, and immediately floating the tile into place. Joints must be straight,

level, perpendicular, and of even width not exceeding $^1/_{16}$ inch. Wainscots are built of full courses, which may extend to a greater height, but in no case more than 1½ inches lower than the specified or figured height. Vertical joints must be maintained plumb for the entire height of the tile work.

5.2.9.4 *Grouting.* All joints in wall tile should be grouted full with a plastic mix of neat white cement immediately after a suitable area of tile has been set. The joints should be tooled slightly concave and the excess mortar cut off and wiped from the face of tile. Any interstices or depressions in the mortar joints after the grout has been cleaned from the surface should be roughened at once and filled to the line of the cushion edge before the mortar. All joints between wall tile and plumbing or other built-in fixtures should be made with a lightcolored caulking compound. Immediately after the grout has had its initial set, tiled wall surfaces should be given a protective coat of noncorrosive soap or other approved protection.

5.2.10 Application of Tile in Existing Construction

Wall tiles installed over existing and patched or new plaster surfaces in an existing building are completed as described in paragraph 5.2.9, except that such wall tiles are applied by the adhesive method.

5.2.10.1 *Priming.* Where wall tile is to be installed in areas subject to intermittent or continual wetting, the wall areas should be primed as recommended by the manufacturer of the adhesive used.

5.2.10.2 *Adhesive Application.* Wall tile may be installed either by the floating method or by the buttering method. In the floating method apply the adhesive uniformly over the prepared wall surface, using quantities recommended by the adhesive manufacturer. Use a notched trowel held at the proper angle to insure a uniformly spread coating of the proper thickness. Touch up thin or bare spots by an additional coating of adhesive. The area coated at one time should not be any larger than that recommended by the manufacturer of the adhesive. In the buttering method, daub the adhesive on the back of each tile in such amount that the adhesive, when compressed, will form a coating not less than $^1/_{16}$ inch thick over 60 percent of the back of each tile.

5.2.10.3 *Setting Tile.* Joints must be straight, level, plumb, and of even width, not exceeding $^1/_{16}$ inch. When the floating method is used, one edge of the tile is pressed firmly into the wet adhesive, the tile snapped into place in a manner to force out all air, then aligned by using a slight twisting movement. Tile should not be shoved into place. Joints must be cleaned of any excess adhesive to provide for a satisfactory grouting job. When the buttering method is used, tile is pressed firmly into placed, using a "squeegee" motion to spread the daubs of adhesive. After the adhesive partially sets, before it is completely dry, all tiles must be realigned so that faces are in same place and joints are of proper width, with vertical joints plumb and horizontal joints level.

5.2.10.4 *Wainscots.* Wainscots are built of full courses to a uniform height. The wainscot height may be adjusted somewhat to accommodate full courses, but the adjustment should not exceed 11/2 inches from the norm.

5.2.10.5 *Grouting* The adhesive should be allowed to set for 24 hours before grouting is done. Joints must be cleaned of dust, dirt, and excessive adhesive, and should be thoroughly soaked with clean water before grouting. A grout consisting of portland cement, lime, and sand, or an approved ready-mix grout may be used, but the grout must be water resistant and nonstaining.

5.2.10.6 *Caulking* Nonstaining caulking compound should be used at all joints between built-in fixtures and tile work, and at the top of ceramic tile bases, to insure complete waterproofing. Internal corners should be caulked before corner bead is applied.

5.2.11 Repair of Ceramic Tile

Cracked and broken tile should be replaced promptly to protect the edges of adjacent tile and to maintain waterproofing and appearance. Timely pointing of displaced joint material and spalled areas in joints is necessary to keep tiles in place.

5.2.12 Cleaning

Newly tiled surfaces should be cleaned to remove job marks and dirt. Cleaning should be done according to the tile manufacturer's recommendations to avoid damage to the glazed surfaces.

SECTION III—REPAIR AND MAINTENANCE OF DRY-WALL CONSTRUCTION

5.3.1. General

Dry-wall construction usually consists of a gypsum wallboard finish. However, other manufactured sheet materials and wood products are also used to provide interior wall construction other than wet plaster. When the following items are used, the

item used should be in conformance with the Federal Specification or Standard cited: gypsum board (AA-L-30); hardboard (LLL-B-810); particle board (ASTM C-208); plywood (Product Standard PS-1-66 or Commercial Standard CS-35-61); acoustical unit prefabricated (SS-S-118A). This chapter deals with the maintenance and repair of these types of dry-wall construction.

5.3.1.1 *Repair.*

a. Fixed- Wall Construction. Maintenance and repair of interior wall boarding generally requires that nails, screws, and other fasteners be kept in a secure condition. Cracks in plaster-type boards may be repaired in a manner similar to plaster repair. Joints which fail in dry-wall construction must be recemented and taped. Broken panels usually are best repaired by replacement of a complete panel. When repairs are completed, finish to match the adjoining area. All fastening, such as nailing, screwing, or gluing, must be at least equal to the "as built" construction.

b. Nonload-Bearing Partitions. Nonload bearing partitions carry no load other than their own weight and are used under floors or roofs that are trussed or framed with beams and girders to carry the superimposed load to the structural frame. Nonload bearing partitions can be less substantial than load-bearing partitions and are usually placed after structural frame, roof, and floors are in place. Periodic inspection of these partitions will be made for marks, dents, scratches, cracks and other surface damage. These nonload-bearing partitions can be repaired, strengthened, plumbed, and aligned without regard to the structural frame or ceilings and may be removed to provide other interior arrangements of space.

c. Trim and Wainscot. Trim and wainscot material will vary to suit design requirements for different interiors. Wood trim and wainscot must be kept nailed, screwed or otherwise secured. When broken areas occur, they should be repaired or replaced with like material and fastening devices. Ceramic tile may occasionally be patched with plaster or plastic materials, but it is usually more suitable to extract the broken piece and replace it with a new one. Joints should be kept in good repair, and new joining material placed where severe spalling occurs. Synthetic moldings must be kept securely fastened to the wall so moisture and dirt do not collect between them and the wall. Mastic of the type used in the original construction should be used for repair or replacement of moldings and wainscots of this type.

5.3.2 Single-Thickness Gypsum Wallboard

5.3.2.1 *Nailing.* Secure gypsum wallboard to supports with 1**d** inch by 0.101-inch, blued, helically threaded, tapered screwnail with medium diamond point. Space nails not less than % inch from edges, 5 to 7 inches apart on ceilings, and 6 to 8 inches apart on walls. Drive nails with heads slightly below the surface, but do not use a nail set.

5.3.2.2 *Finish Joints.* Square-edge sheets are recommended for temporary construction. Sheets with ½- to $^{3}/_{16}$-inch bevel on the long edges are used where the joint is featured. The recessed-edge sheet is used where a concealed reinforced joint is desired. Finish of recessed joint consists of filling the recess with cement, into which a perforated tape is imbedded. A thin covering coat of cement is applied over the tape. Second and third coats of cement are applied after preceding coats are dry. When the last coat of cement is dry, the joint should be sandpapered smooth and level with the rest of the wall.

5.3.2.3. *Gypsum Backing* For backing glazed or other wallboard linings and wainscots, use gypsum plasterboard, conforming to Federal Specification SS-L-30. Install boards horizontally with joints staggered. Secure to supports with 13-gage, blued or cement-coated, 1 $^{5}/_{16}$-inch flathead nails, spaced about 4 inches apart on all bearings.

5.3.2.4 *Limitations.* Maximum spacing of bearings should not exceed 24 inches. Gypsum board should not be installed in damp places such as showers and bathrooms. Do not use gypsum board as a base for attaching tile or other materials with adhesives.

5.3.3 Double-Thickness Gypsum Wallboard

5.3.3.1 *Planning* A double thickness of gypsum wallboard is produced on the job by laminating two thicknesses of **d**-inch gypsum wallboard, using a special adhesive to bond the layers. The resulting walls are strong, can stand heavy abuse, and are very resistant to cracking and sound transmission. On walls not more than 8 feet 3 inches in height, the first layer is applied vertically, with edges centered on and nailed to studs. The second layer of wallboard is then applied horizontally across the studs. Where the ceiling is between 8 feet and 8 feet 3 inches, the gap is filled in with scrap strips and concealed by the baseboard. Where wall lengths exceed 12 feet, vertical end joints are staggered to fall between, not on, framing members. Use wood cleats on the face of the board to hold the ends in place until the adhesive has set, and then remove them. Use 12-foot panels, wherever practical, to minimize end joints. Where

walls exceed 8 feet 3 inches in height, it is more practical to apply the first layer of wallboard horizontally, breaking all end joints between studs, where 12-foot boards will not span the wall length. The face layer is then applied vertically, with full-length boards extending from floor to ceiling, eliminating all the joints. Where joints in the first and second layers are parallel, they should be offset at least 10 inches. Edges of the face layer should be centered on and temporarily nailed to the studs.

5.3.3.2 *Application.* Make a thorough inspection of the framing before applying the first layer of wallboard. Studs and joists should be in true alignment. Soil pipes, bridging, fire stops, etc., must not protrude beyond framing members. To insure proper application of the second or face layer of wallboard, a definite plan for erection should be formed before the first layer of the board is applied. Ceiling height will determine whether the base layer is vertical or horizontal. Apply the base layer with 1 **d** -inch by 0.101-inch blued, helically threaded, tapered screwnails with medium diamond point spaced 8 inches on centers. Cut the face layer panels to correct size. Prepare the laminating adhesive cement in accordance with the wallboard manufacturer's recommendations. Using a notched spreader blade, spread the mixed cement uniformly over the entire back surface to the extreme edges of the board. After the board is in place, wipe away any cement forced out along the edges. When the face layer is applied horizontally, apply the first sheet to the upper wall. With temporary nailing, secure the board in place until the cement has set. Secure long edges by nailing wherever they occur on or across framing members. On walls, space nails in the center of the board 16 to 24 inches on centers. Following application of the upper panels, place the lower face panels. Butt the top and lower panels closely together.

5.3.3.3 *Finishing Nail Holes and Joints.* All temporary nails should be countersunk at least **d** inch with $^{5}/_{32}$-inch nail set. This is done after the face layer has been in place long enough for the cement to dry. Cement dries in 24 hours, but under adverse conditions, allow 48 hours. Fill nail holes with a joint cement mixed to a puttylike consistency. For tapered joints, spot nail holes with joint cement and then finish as normal tape-reinforced, recessed joints. Butt or square-end joints are treated the same as tapered-edge joints. However, finishing coats of joint cement are feathered wider (approximately 24 inches) because there is no taper in which to embed the tape.

5.3.3.4 *Spreader Blade.* A metal cement spreader blade is recommended. With blades made of other materials, the cement tends to accumulate in the notches and dry, preventing proper spreading action. Stainless steel or galvanized steel make the best spreaders. The spreader should have the approximate stiffness of a plaster trowel blade. The blade should be kept reasonably clean at all times. A 10-inch blade is most effective for spreading the cement.

5.3.4 Cement-Asbestos Wallboard

Cement-asbestos board is no longer used.

5.3.5 Insulation Board

Make all joints between boards over solid bearings and bring edges of board into moderate contact, but do not spring into place. Nail boards with 1½-inch, blued plasterboard nails spaced 6 inches on centers along edge bearings and approximately 12 inches on centers at intermediate bearings.

5.3.6 Hard-Pressed Fiberboard

This type material may only be used as wainscoting when backed with noncombustible material, such as gypsum wallboard. When a structural-type fiberboard is required, use $^{5}/_{16}$-inch material conforming to Federal Specification LLL-B-810. Where moisture resistance or extra strength is required, install Type II fiberboard; otherwise, Type 1 is suitable. Installation is similar to that described previously for insulation board. Make certain that material is preexpanded before installing Type II fiberboard in areas subject to moisture or steam, or in very humid localities. To do this, scrub the fiberboard on the screen side with a stiff broom and cold water until it turns a very dark brown (chocolate), or a decided black in the case of the black-treated board. Following this, stack the wetted boards face to face and wetted back to back, and allow them to remain in this position overnight or preferably for 36 hours.

5.3.7 Glazed Wallboard

Glazed wallboard suitable for wainscots consists of a base material with a factory-applied finish. It may only be used when backed by noncombustible material. The base may be made of asbestos fiber and cement formed under pressure into dense, monolithic sheets, a structural-type fiberboard, or a hard-pressed gypsum sheetrock. Finish on exposed face is a factory-applied gloss coating. A variety of colors are available, such as white, ivory, yellow, peach, green, blue, red, and black. In addition to these colors, other finishes give the appearance of several woods, such as walnut, mahogany,

knotty pine, oak, and red gum. Most boards are made in 4-foot widths and lengths of 4 to 12 feet. Thickness range from **c** to **d** inch. The **d**-inch-thick boards can be applied by nailing over furring strips, in which case make all joints over solid bearings and secure with 1¼ inch, 18-gage brads, driven ¼ inch from edges on 4- to 6-inch spacings and about 12-inch spacings through the body of the board. An alternate method of installation consists of spreading an adhesive over a smooth, solid backing of noncombustile material such as gypsum wallboard. Cut and fit glazed boards to a close fit. Lay the board on the adhesive-coated wall or ceiling and push firmly into place. Do not spring into place. Clean off any excess adhesive that may appear at joints, using cleaner recommended by the board manufacturer for that purpose. Immediately after setting the board in position, insure solid contact with backing by placing previously prepared braces. Leave the braces in place until the adhesive sets, usually overnight. For some applications, brads may be used to support the boards while the adhesive sets. The nails may be either countersunk or withdrawn and the holes filled with material matching the board finish. Panel effect, if desired, is obtained by installation of moldings over board joints and around openings. These moldings are available in a variety of sizes, colors, and materials, such as wood, plastic, metal alloys, and stainless steel.

5.3.8 Plywood Linings

Plywood acceptable for interior wall and ceiling linings will be equal to or better than three-ply softwood plywood, interior grade, not less than ¼ inch thick, manufactured in accordance with the requirement of Product Standards PS 1-66. It may be used when backed with noncombustile materials. Face veneer may be Douglas fir or other softwood or hardwood with smooth surface suitable for painting or staining. The economical procedure generally calls for the installation of the larger size sheets. Before starting the installation, see that stud, furring and ceiling joist spacings do not exceed 24 inches on centers. Make all joints, including end joints, over solid bearings. Fit panels close but do not force into place. Secure with six-penny nails spaced 6 inches on centers on intermediate bearings. Plywood for wainscots is usually set with the grain running horizontally. Plywood for wall lining is set with the grain running vertically. Grain of plywood on ceiling should be parallel with the long dimension of the room.

5.3.9 Furring in Walls

5.3.9.1 *Placing* When applying interior surfacing materials, install furring strips vertically, spaced not more than 2 feet on centers. It is also advantageous to place other furring strips so that each sheet of surfacing material is supported horizontally at distances of about 4 feet on centers. Wood furring strips supporting metals lath and plaster are spaced 16 inches on centers. Furring strips are also installed around all openings or wherever proper installation of wall, partition, or ceiling lining requires their use.

5.3.9.2 *Fastening* Furring strips may be secured to masonry walls by the methods given below.

a. Cut or case-hardened nails placed on 2-foot centers provide a simple and satisfactory way to fasten furring strips to walls or ceilings. The wedging action of a cut nail gives additional holding power. Furring strips are leveled or plumbed by inserting wooden wedges under the nailing point.

b. The same procedures used for nailing are used for bolting. Toggle bolts or butterfly bolts can be used to attach furring strips to hollow-core masonry material. The use of bolts requires drilling a hole in both the strip and the masonry. This method is slower than nailing and should be used only when the superior holding power of a bolt is required.

c. Powder-Actuated Tools. The development of powder-actuated tools has provided a means of fastening any construction material to steel or concrete with great speed and ease. A wide variety of pins and studs are available to suit the needs of the job at hand. The pins are placed in the tool, similar to a handgun, and fired into place by a special powder charge. These tools can be used to fasten furring strips to masonry, as well as for a variety of other uses. The tool requires a trained operator and observation of prescribed safety procedures.

5.3.10 Furring in Ceilings

5.3.10.1 *General.* Ceilings are furred to obtain straight surfaces and to correct any difference in level on the underside of the joist. Furring strips, spaced 12 to 16 inches on centers, are run perpendicular to the underside of the floor or ceiling joists and secured with 10-d nails. These strips are brought to even surface by working from leveled furring strips extending around the perimeter of the ceiling.

5.3.10.2 *Fastenings.* Furring strips intended to support plaster or acoustical materials on the ceilings should be nailed and tied securely by 16-gage

wire to the underside of the joists. When wooden joists are used, convenient hangers are formed by driving 10-d nails into each side of the joists. A wire extending from one nail to another, looped and drawn taut across the furring strip, forms a secure anchor. When open-web joists are used, nailing is accomplished by means of metal nailing grooves or wooden nailers. Wire loops, encircling the furring strips and the lower chord of the joists, can be spaced as required.

SECTION IV—FIRE PROTECTION

5.4.1 General

In the course of necessary repairs to buildings and structures, fire protection features will be reexamined and any deficiencies corrected promptly. Adequate fire protection is a function of design, but such changing conditions as additions to buildings and structures, change in occupancy, or introduction of increased operational hazards may require upgrading of protective features or additions to them. In any case, the effectiveness of fire protection features depends on regular inspection, care, and maintenance. (Fire protection standards may be obtained from the National Fire Protection Association (NFPA) Standards.) (Air Force Standards are found in AFM 88-15.) The extremely rapid flame spread that occurs on the surfaces of commonly used materials has been the cause of many catastrophes. In view of the past record, the use of combustible wall and ceiling finishes (including wallboard and acoustical units) having high flame-spread ratings is prohibited. Certain interior finishes that have a rapid flame-spread rating were widely used in the past and remain in use in some buildings. The generation of smoke and fumes resulting from the combustion of material must also be taken into consideration. Interior wall and ceiling finishes are applied over structural framing of a building and cover a considerable portion of the individual walls or ceilings. Such materials include decorative finishes, acoustical corrections, and surface insulation. Surface coverings of wallpaper, not exceeding 0.025 inch thick, or a material with no greater fire risk than wallpaper, do not contribute significantly to fire hazards when applied over a noncombustible base. Generally, plaster finishes have been accepted by building codes, and wallpaper or paint finishes over noncombustible surfaces are considered nonhazardous if any coatings are not applied one over the other.

5.4.1.1 *Noncombustible Interior Finishes.* Fire resistance and flame spread are different properties of construction materials. Fire-resistant ratings have been established for wall, partition, and ceiling construction by responsible and extensive laboratory tests. Conventional wall construction, such as brick, concrete, hollow tile, and concrete or gypsum block units surfaced with plaster of the required thickness, is considered nonhazardous and noncombustible. Similarly, partitions or ceilings constructed of assemblies of wood or metal studs and joists, or of metal, gypsum, or wood lath surfaced with cement, lime, or vermiculite plaster have nonhazardous interior surfaces and, depending on the assembly, the required fire rating. Sheet-metal covering applied directly to wood joists or over old plaster ceilings, although superior to highly combustible materials, offers little resistance and increases the effort required to extinguish fires starting in concealed spaces between the joists.

5.4.1.2 *Insulation and Sound Control Materials.* Insulation and sound control problems are similar, principally because the same materials (treated and untreated) are often used for insulating buildings for heat or cold (thermal insulation) and for sound control (acoustical correction).

5.4.1.3 *Fire Resistance.* Noncombustible insulating material, such as mineral or glass wool, may increase fire resistance if it will stay in place and not settle and produce voids. Standard fire tests have shown that mineral wool in the hollow spaces between studs increases the fire resistance of metal lath and sand gypsum plaster on wood stud partitions by about 30 minutes. For gypsum board facing on wood stud, the fire resistance is increased by 10 to 20 minutes.

5.4.2 Alterations

When alterations are necessary to existing buildings, the fire protection features should be reexamined to correct deficiencies and provide such additional measures as the new use requires. The following features are most important.

5.4.2.1 *Firewalls.* Firewalls are protection against the horizontal spread of fire only if they are intact, and if openings were permitted, are properly protected against passage of smoke or heat. Interior finish repairs must be accomplished without damage to firewalls, and finishes applied should have a flame spread rating equal to finishes used on other interior walls for a particular occupancy. When hazards are increased in existing buildings and structures, firewalls should be added as needed to subdivide the space into suitable limited fire areas; this can often be done economically by increasing the fire resistance of existing walls and

installing fire doors. If area limitations require firewalls through combustible roof structures, the walls should be parapeted.

5.4.2.2 *Vertical Openings.* The enclosure of vertical openings is most important in preventing the vertical spread of fire. In fact, it is probably the largest factor in connection with life and property safety in multistory buildings. If masonry walls cannot be placed around open stairways or elevator shafts in an existing building, metal lath and plaster, or other lightweight construction of equal fire resistance, may be used. Any enclosure is preferable to open stairs or elevator shafts.

5.4.2.3 *Horizontal Openings.* All wall openings will have fire protection features appropriate to the occupancy of the building and structure. This is especially important for areas where hazardous processes are carried on or hazardous materials are stored in buildings or structures with a large total floor area. The adequacy of horizontal opening protection should be checked and preserved in the course of interior repairs. If swinging fire doors are used to replace sliding doors, such doors must swing in the direction of the emergency exits.

5.4.2.4 *Concealed Spaces.* Concealed spaces exposed in the course of repairs will be checked for the presence of combustible debris. Materials used for insulation will be noncombustible. Any draft stop helps slow the spread of fire, but complete fire stopping may be difficult in open-joist channels and stud-spaced wood construction. Fire stops should be used between the wood joist and sills. The use of fire-retardation paint or solution may be helpful in particular cases, but this provides only a temporary measure of protection.

5.4.2.5 *Skylights.* Skylights and other small structures on the roofs of buildings should have a fire-resistance rating appropriate to the construction and occupancy. Skylights should be maintained to insure their effectiveness in preventing the entrance of fire and venting interior fire or explosion.

5.4.2.6 *Ventilation Ducts.* Ventilation or exhaust and intake ducts extending through roofs or walls should be of noncombustible materials. Ducts should be cleared of obstructions as required. Ventilation hoods, ducts, and filters in kitchens should be periodically cleaned to remove grease accumulation that may cause fire. Devices to prevent the entrance of sparks or brands, such as baffle plates, vanes, dampers, and metal screens, should be checked regularly for proper setting and good condition.

SECTION V—ACOUSTICS

5.5.1 Acoustical Problems

Acoustical materials applied on walls, partitions and ceilings of theaters, auditoriums, and many other occupancies absorb noise and aid hearing by reducing echoes and reverberation. Two acoustical problems are to be considered. One is the treatment of a room or building to keep out exterior sound, and the other is the treatment of a room interior to eliminate echo and reverberation by sound absorption or diffusion to reduce objectionable noise levels.

5.5.1.1 *Exterior Sound.* Insulation from exterior noise is sometimes part of the interior sound-absorption problem. The best resistance to noise penetration usually can be obtained with heavy rigid walls and floors, or multiple-layer construction separated by airspaces. Such construction keeps out sound by preventing the vibration of the wall or floor. Any mechanical connection across the intervening airspaces in a structurally separated wall increases sound transmission. For hollow walls not structurally separated, such as ordinary wood stud partitions, a fill of noncombustible material between the studs slightly improves the sound insulation.

5.5.1.2 *Sound Absorption.* For best results, sound absorption requires porous or low-density materials, but it is impossible to set rules applying equally to every installation. However, it is necessary to use only noncombustible materials that do not have surface flame-spread characteristics and will not add fuel to a fire that may occur in the treated spaces.